

THE ROLE OF THE FLORIDAN AQUIFER IN DEPRESSIONAL WETLANDS

HYDRODYNAMICS AND HYDROPERIOD

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Abstract. Debate exists over the primary hydrologic driving variables controlling hydroperiod and hydrologic variation of seasonal Coastal Plain wetlands. Previous studies approached these wetlands as isolated systems and related depression's hydrology to precipitation, evapotranspiration and local surficial groundwater inflow. In the Dougherty Plain, the Floridan aquifer emerges with the aquifer water table 0 to 25 meters below the ground surface. While aquifer-emergence wetlands exist, a number of depressional wetlands exist whose surface water chemistry do not indicate direct aquifer discharge. This study focused on these depressional wetlands to determine the potential role of the aquifer on their hydrology. Ten wetlands of varying size and vegetative characteristics were studied. The wetlands were located in the lower Ichawaynochaway Creek drainage basin. Wetland hydroperiod and hydrodynamics were significantly ($R^2 = 0.79$ to 0.93) related to Floridan aquifer level, precipitation and estimated evapotranspiration. The Floridan aquifer water elevation explained the greatest amount of the variation in the wetlands hydrodynamics and hydroperiod. The relationship between wetland pond water level and aquifer water level exhibited 3 distinct patterns (linear, concave and "broken stick"). The broken stick relationship suggested that there were critical elevations in the aquifer in which the wetland pond varied as a linear function of aquifer level then beyond that break point other factors such as temperature or precipitation were more important in wetland pond dynamics. The break point was similar among wetlands varying less than 0.5 meters.

INTRODUCTION

Background

Depressional wetlands are a conspicuous feature of the Atlantic and Gulf Coastal Plain physiographic region of the southeastern United States. In areas like the Dougherty Plain of southwest Georgia, where the aquifers are exposed or the unconsolidated overburden is relatively thin, these

wetlands are likely karstic resulting from the dissolution of the underlying limestone bedrock. Depressional wetlands range from small holes with steep sides to shallow, flat expanses of several hectares (Wharton 1978) and depths of a few decimeters to 8 m (Torak et al. 1991). Wetlands with relatively pervious sediments contain water intermittently while those containing more impervious clays retain water longer (Hayes et al. 1983). Forested depressions occur in the greatest abundance but numerous herbaceous, aquatic bed and scrub-shrub wetlands occur (Rowell et al. 1995).

Debate exists over the primary hydrologic driving variables controlling hydroperiod and hydrologic variation of seasonal Coastal Plain wetlands (Phillips and Shedlock 1993, Crownover et al. 1995, Lide et al. 1995). Wetland water elevations are influenced by local groundwater controls (Crownover et al. 1995). Wetland water tables can increase through inflow from surrounding areas and groundwater flowing through wetland areas in response to generalized groundwater surface elevation. Wetland water elevations decline through flows from the wetland to the surrounding area in response to water use by upland plants or differential storage between wetland basin and surrounding soils. The pattern of groundwater exchange is related to average water table elevation. Study of wetlands in the Dougherty Plain suggest that precipitation and evapotranspiration drive the hydrologic regime and that surficial ground water interaction occurs only during periods of extremely high water-table elevation (Hendricks and Goodwin 1952, Hendricks 1954). Depression morphometry obviously influences wetland inundation patterns, however, the relationship of the watershed elevation and stratigraphy of the subsurface components to the hydrologic regime is less certain (Crownover et al. 1995, Winter and Rosenberry 1995).

Research Objectives

Studies of wetland hydrologic regimes in areas with near surface aquifers are scarce (Crownover et al. 1995, Hendricks and Goodwin 1952,). In Karst terrains, direct linkages to the aquifer may greatly alter local wetland

watershed controls and processes. Broad functional attributes, such as hydrologic recharge to deep aquifer systems from depressional wetlands have been implied (Wharton 1978, Hayes et al. 1983). However, few studies have attempted to verify this relationship. Torak et al.'s (1991) simulation of the Floridan aquifer water elevation and flow paths for a 3900 km² area in the Dougherty Plain clearly identified depressional wetlands which were recharge and discharge features of the aquifer. Within the Dougherty Plain, the Floridan aquifer is highly fractured and the thickness of the clay confining layer between the aquifer and residuum overburden is highly variable and not contiguous (Hayes et al. 1983). These discontinuities permit hydrologic linkages between the regional aquifer and the local residuum (or surficial) groundwater. The objective of this study was to determine climatic, surficial groundwater and potential deeper aquifer controls on depressional wetland hydrologic regimes.

Significance to Conservation Issues

There is little regulatory protection and no comprehensive management of non-riverine depressional wetlands. While these wetlands are operationally defined as "isolated" wetlands, it is not clear how independent they are from larger hydrologic systems, each other, or the Floridan aquifer. Their functional role with the Floridan aquifer has not been appreciated or addressed in any management context. Many of these depressional wetlands are relatively small and as such fall outside of most federal protection. Wetlands under 10 acres are exempt from regulation under Section 404 of the Clean Water Act. Nationwide Permit 26 of the USCOE permits alteration of wetlands less than 10 acres that are isolated from or above riverine headwaters. Many depressional wetlands fall into this category. Under the "Swampbuster" provisions of the Food Security Act (1985) and the current Farm Bill (1996) conversion and draining of wetlands for agriculture is permitted. As much as 14% of the depressional wetlands in the central Dougherty Plain may have been lost by agricultural conversions (Rowell et al. 1995).

Loss of hydrologic function may be occurring from lowering of the Floridan aquifer by residential and agricultural withdrawals. Per capita residential water use of the Floridan and Claiborne aquifers is 30 MGD (Marella et al. 1993). Municipal water withdrawals in 1990 for the city of Albany average 17 MGD. In 1990, five counties (Decatur, Seminole, Miller, Mitchell and Baker) within the Dougherty Plain withdrew 66% of the total groundwater withdrawals for agricultural use within the Flint River Basin (Couch et al. 1996). The estimated withdrawals within the Lower Flint River is 178 MGD (Marella et al. 1993) and this irrigation demand (MGD) is expected to double by 2020 to 314 MGD. Most of these withdrawals were from the Floridan aquifer. Simulation modeling of the Floridan aquifer shows that current demands locally lower the Floridan aquifer water elevation and that there is a line

decline in aquifer water elevation proportional to projected increased pumping (Torak et al. 1991, Torak et al. 1996). What is needed is a quantitative assessment of the hydrologic functioning of representative depressional wetlands with specific evaluation of the Floridan aquifer linkages and a comprehensive means of extrapolating those results to the larger wetland complex and the Floridan aquifer.

SITE DESCRIPTION

The study area is located in the central Dougherty Plain near the confluence of Ichawaynochaway Creek and the Flint River (Figure 1). The center of the study area is located approximately 50 km south of Albany, GA. The Dougherty Plain is a karstic feature located in southwest Georgia between the Chattahoochee River and Fall-line Hills to the west and north, and Pelham Escarpment to the south and east (Beck and Arden 1983). It has relatively low topographic relief (averaging <1%) with a mean sea level elevation of 49 m. The karstic topography results in the formation of numerous depressional wetlands from the solutioning of underlying limestone bedrock. Debate exists over the formation and evolution of these depressional wetlands. It has been proposed that younger depressions are collapse or solution features which drain into the underlying residuum and as the wetland ages the bottoms become sealed by an impermeable layer of silt and clay (Hendricks and Goodwin 1952, Hayes et al. 1983). As the wetlands age their hydrodynamics become independent of aquifer variation.

The Dougherty Plain geology is composed of three major geologic units. The undifferentiated overburden is composed of sand and clay, with clay content increasing with depth (Hayes et al. 1983). This residuum ranges from 6 m to 37 m (Hicks et al. 1981). Beneath the residuum lies the Ocala limestone which is the primary rock layer bearing the Floridan aquifer (Hicks et al. 1981, Beck and Arden 1983, Hayes et al. 1983). It ranges in thickness from 15 to 100 m and is highly fractured and porous (Beck and Arden 1983, Hayes et al. 1983). Due to its porous nature, hydraulic conductivity and transmissivities are relatively high and it is hydraulically connected to the water table of the overburden (Hayes et al. 1983, Hicks et al. 1987). The Ocala limestone outcrops along the Flint River and it's major tributaries. Aquifer flow on the Dougherty Plain discharges into the Flint River or major tributaries (Beck and Arden 1983, Hayes et al. 1983).

Wetlands comprise approximately 10% of the study area and approximately 20% of the central Dougherty Plain (Rowell et al. 1995). Depressional wetlands are 29% of the wetland habitat. Ten wetland wetlands were studied (Table 1). They range in size from 0.5 to 16.5 ha. They occur at 42.3 to 54.7 m MSL. The surrounding wetland watersheds were gently sloping (0.5 to 2%). Soils within the wetland

basins are primarily loamy sands grading into clayier soils in the depressions. The clay layer occurs at shallower depths with proximity to the wetland. Wetlands studied included forest, shrub-scrub and herbaceous vegetation. The uplands generally supported mature longleaf pine forest.

METHODS

Wetland stage, surrounding watershed groundwater stage and rainfall were monitored weekly from July 1994 to October 1996. Stage measurements were converted to elevations relative to mean sea level for all statistical analyses. Wetland stage was measured using metal plate staff gauges. Surficial ground water wells were installed to 3 to 4 m below ground surface. The wells were constructed of 1.5 inch PVC pipe screened from top to bottom and backfilled with sand. A six inch PVC pipe collar was installed around the well and excavated to a depth of 3 inches. Well heads were then capped below ground surface and the 6 inch PVC collar covered with masonry plates to prevent exposure to seasonal fires present on the research site. In addition, the masonry cover inhibited rainwater from running down the side of the well. An electronic water level indicator was used to obtain the depth to water table. A standard rain gauge was installed at the site and total rainfall occurring between weekly sampling was recorded. Wells, wetland wetlands staff gauges and rain gauges were surveyed to known USGS bench marks to determine mean sea level elevations. Aquifer water level data were obtained from a USGS Floridan Aquifer well (09H014) located 12 km southwest of the center of the study site.

RESULTS AND DISCUSSION

Rainfall and Evapotranspiration

The climate of south west Georgia is sub-tropical with average annual temperatures 18.4 C with a mean monthly low of 8.3 C in January and a mean monthly high of 27.3 C in July (National Oceanic and Atmospheric Administration Climatic Data Center data for Albany, GA). The 30 year average annual rainfall is 1210 mm and is evenly distributed throughout the year. Maximum monthly rainfall is 153 mm in July with minimal rainfall (56 mm) in October. The weekly rainfall for the study period is presented in Figure 2. The study period represents one year that had the highest rainfall on record (1994 - 1940 mm) with the following 18 months close to average conditions (Figure 3). Evaporative losses were estimated at 915 (1996) to 966 (1995) mm using the Thornthwaite equation. Evaporation exceeded rainfall during summer months resulting in net monthly rainfall deficits of 5 to 128 mm.

While inter-annual variation in hydroperiod was related to excess rainfall, rainfall and evapotranspiration generally explained little of the wetland weekly water elevation.

Wetland surface water averaged 58 cm in depth for the study period (Table 2). The shallowest wetland (#36) averaged 28 cm and the largest and deepest (# 46) had an average depth of 1 m. The wetlands were filled during a tropical storm in July 1994 and retained water for an average of 372 days. The wetlands were dry for 167 days beginning in July 1995. The wetlands were inundated between December 1995 and February 1996 and remained wet for an average of 146 days. The dry period beginning in June 1996 was approximately half (87 days) of the previous year. Wetland 46 had the longest period of inundation (714 consecutive days) and the shortest dry period (77 days). While regressions of weekly rainfall amount and evapotranspiration to weekly wetland water elevation were significant, they explained little of the weekly wetland variation. Regression coefficients ranged from $R^2 = 0.05$ to 0.26. The exceptions were wetlands #46 ($R^2 = 0.63$) and #36 ($R^2 = 0.73$).

Studies of depressional wetland have shown differing importance in the controls on hydrologic regimes. While most have acknowledged that precipitation and evapotranspiration were important, their importance vary seasonally and among wetlands. In these wetlands, seasonal hydrodynamics were related to excess seasonal precipitation and evapotranspiration patterns. The amount of stage change varied among wetlands but they all showed the same general dynamics. Evapotranspiration was the dominant hydrologic process during summer months resulting in net rainfall deficits and declining wetland stage and eventual dryness. July has the highest rainfall input but it is the period of highest evapotranspiration. The evaporative controls could be overridden by large rainstorms. During August 1996, rainfall exceeded evapotranspiration by 25 cm and filled the wetlands. The wet period in 1994 was initiated by a 61 cm rain storm which occurred in 24 hours in the study watershed. The continued occurrence of tropical storms resulted in precipitation exceeding evapotranspiration from July 1994 to April of 1995. This period coincided with the highest water elevations measured in the wetlands and no seasonal dry period in 1994. Wetland water elevation began to drop succeeding each year when effective precipitation (precipitation - evapotranspiration) approached zero and the wetlands generally were dry when evapotranspiration was a maximum summer levels. The wetlands remained dry in 1995 until seasonal effective precipitation reached 21 cm.

Surficial Groundwater

Clear differences in precipitation and evapotranspiration controls on water elevations were evident among the wetlands when weekly periods were considered. Our study showed that in only two open herbaceous wetlands (36, 46) were precipitation and evapotranspiration the most important factors in predicting weekly changes in wetland water elevations. For the remaining eight wetlands, contributions from the surficial ground water of the

Table 1. Description of Wetlands and Surrounding Watershed Soils

Wetland	Vegetation	Elevation m MSL	Area sq. m.	Soil Composition	Soil Texture	Hydric Classification
3	Mixed Cypress/Hardwood Forest	48.34	23133	Wagram/Grady	LS/FSL	A/D
Sand Pond	Open Herbaceous	42.06	164993	Intermittent/Grady/Albany	FSL/S	D/C
32	Mixed Cypress/Hardwood Forest	45.36	27767	Wagram/Grady	LS/FSL	A/D
36	Open Herbaceous	52.60	20344	Norfolk/Grady	LS/FSL	B/D
39	Forested - Cypress	53.49	11813	Wagram/Grady	LS/FSL	A/D
40	Forested - Cypress	53.89	14079	Wagram/Grady	LS/FSL	A/D
41	Forested - Cypress	54.25	4609	Wagram/Grady	LS/FSL	A/D
46	Open Herbaceous	49.95	91040	Grady/Pelham	FS:/LS	D/D
King Pond	Open Herbaceous	54.70	26471	Wagram/Grady	LS/FSL	A/D
Dude Williams	Mixed Cypress/Hardwood Forest	46.60	81444	Wagram/Grady	LS/FSL	A/D

Table 2. Mean Wetland Water Depth and Minimum, Maximum and Mean Wetland Water Elevations

Wetland	Mean wetland depth (m)	Mean elevation m MSL.	Minimum elevation m MSL.	Maximum elevation m MSL.
3	0.61	48.95	48.34	49.28
Sand Pond	0.81	42.86	42.06	43.15
32	0.49	45.85	45.36	46.14
36	0.29	52.89	52.60	53.11
39	0.50	53.99	53.49	54.35
40	0.48	54.37	53.89	54.71
41	0.66	54.91	54.25	55.15
46	1.00	50.95	49.95	51.40
Dude Williams	0.51	47.11	54.70	55.70
King Pond	0.70	55.40	46.60	47.39

Table 3. Regression Coefficients of Wetland Water Elevation with Precipitation, Evapotranspiration, Adjacent Watershed Surficial Groundwater Elevation and Floridan Aquifer Water Elevations.

Wetland	Precip. & ET	Surficial Grd. Water	Surficial Grd. Water, Precip. & ET	Floridan Aquifer	Floridan Aquifer, Precip. & ET	Non-linear Floridan aquifer, Precip. & ET
3	0.09	0.49	0.54	0.76	0.78	0.89
32	0.26	0.54	-	0.67	0.83	-
36	0.73	0.73	0.75	0.83	0.93	-
39	0.15	0.86	0.90	0.85	-	0.98
40	0.12	0.80	0.85	0.85	0.86	0.98
41	0.06	0.80	0.93	0.83	-	0.99
46	0.63	0.59	0.72	0.82	0.86	0.95
Dude Williams	0.11	0.52	0.60	0.81	0.85	0.86
King Pond	0.05	0.94	0.96	0.86	0.87	0.96

*All regressions are linear unless otherwise noted. "-" represents no improvement in the regression coefficients by adding additional independent variables.

contributing watershed were more important in predicting wetland water elevations. Linear regressions of weekly surficial groundwater elevation and wetland water elevation were significant and the regression coefficients ranged from 0.49 (# 3) to 0.94 (King Pond). When rainfall, evapotranspiration and surficial groundwater were included in the regression, there was a slight improvement in the predictive relationship. Regression coefficients increased to 0.54 (# 3) to 0.96 (King Wetland).

To determine the significance of surficial groundwater inflow on wetland stage, the ratio of stage rise to precipitation were compared. If the ratio is greater than one, the rise in stage can be assumed to be due to groundwater seepage. For all but one wetland, water level increases in the wetland exceeded the amount of rainfall input by an average of 1.6. The ratios ranged from 1 (#41) to 2 (#36, #46). Similar contributions have been shown for prairie potholes (Winter and Rosenberry 1995) and Carolina bays (Lide et al 1995). Hendricks and Goodwin (1952) concluded that rainfall and evapotranspiration were the major controls for 13 limesink depressional wetlands located near the current study. They attributed surficial groundwater controls to relatively short periods of extreme high water. In their conclusions, they did not address the fact that six of the wetlands they studied had significant regressions coefficients for groundwater when predicting wetland water level. In addition, the ratio of rainfall to wetland stage ranged from 1.5 to 4.1 for their wetlands, again supporting the significance of surficial groundwater influences.

Only a small portion of the water that falls on the surrounding watershed is transported laterally to the wetland. Rain inputs to the surrounding watershed resulted in an 8 fold increase in surficial groundwater elevation. This large elevation change in surficial ground water resulted in a net groundwater stage (surficial groundwater elevation-wetland water elevation) of 0.24 m for eight of the wetlands. Most of the surficial groundwater head was not transported laterally to the wetland as wetland water elevation increased an average of 0.12 mm for every 1 mm change in groundwater head. Following rain input, the surficial groundwater rises and declines rapidly with the majority of the water being transported vertically recharging the surficial water table or to deeper groundwater. The soils of the surround watersheds were sandy to sandy loams with increasing clay horizontally toward the wetlands and occurring at shallower depths below the land surface with proximity to the wetland. The permeability of the watershed sandy loams is 6 to 20 in/hr while the Grady soils characterizing the wetlands interior is 0.2 to 0.6 in/hr. The sandier outer soils would permit more rapid vertical movement and the increasing clay content with proximity to the wetland would decrease lateral movement. Two of the wetlands (3 and 32) had water level gradients with the surrounding watershed that suggested a net export from the wetlands to the surrounding watershed. The surficial

groundwater elevation averaged 1 meter below the wetland water elevation. The surrounding watershed surficial ground-water elevation in these two wetlands was above the wetland water level for only a short period during seasonally high groundwater tables. Therefore, two of the wetlands exhibited responses similar to those described by Hendricks and Goodwin (1952).

Floridan Aquifer

The single best predictor of wetland weekly wetland water elevation was the Floridan aquifer. Aquifer water elevation for the study area averaged 40.4 m MSL and ranged from a low of 36.6 m MSL in November 1995 to a high of 44.5 m MSL in October 1994. The aquifer water level averaged 5 to 15 meters below the actual land surface of the wetlands. The wetland water elevation and the Floridan aquifer elevation both followed similar seasonal patterns which were not clearly related to rainfall excesses and deficits. Seasonal high aquifer and wetland water elevations occurred approximately one month after the peak in excess rainfall. In general, the wetlands were dry when the aquifer elevation dropped to ~ 38 m MSL and remained dry as the aquifer elevation continued to drop to ~ 36.5 m MSL. Seasonal lows in the aquifer and wetland 46 elevations occurred about two months after seasonal peak rainfall deficits. The wetlands began retaining water approximately one month before the aquifer water elevation began to increase in the spring and again in August of 1996. During summer and fall of 1994, aquifer groundwater elevation remained high and did not decline to normal seasonal lows. The aquifer elevation did not drop below 39.5 m MSL for that period. Linear regressions of weekly wetland water elevations and the Floridan aquifer groundwater elevations were significant and had linear regression coefficients that ranged from 0.67 (# 32) to 0.86 (King Pond). Adding rainfall and evapotranspiration to the linear regressions generally improved the predictive relationship (R^2 from 0.78 to 0.93). Graphical analyses showed three different relationships between wetland water elevation and aquifer groundwater elevation (linear # 32 & #36; curvilinear #3, Sand Pond, Dude Williams; and distinctly non-linear King Pond 46, #41, #40, & #39). A non-linear analysis was conducted to determine where the break (i.e. aquifer water elevations) in the relationship with the aquifer occurred and what factors were contributing to the residual variation. Nonlinear regression coefficients for wetland #3, Sand Pond, Dude Williams were 0.89, 0.73, and 0.86, respectively. For the remaining wetlands, the non-linear regression coefficients were 0.96, 0.95, 0.99, 0.98, and 0.98, respectively. Below 41.5 m MSL (+ 0.2 m), wetland water elevation was a linear function of Floridan aquifer elevation and above 41.5 n MSL both rainfall and evapotranspiration were important in the variation in weekly water elevations.

No studies to date have demonstrated the effects of larger groundwater systems on depressional wetlands.

Studies that have addressed groundwater influences were relating shallow groundwater inflow and outflow to wetland dynamics (Crownover et al 1995, Lide et al 1995, Winter and Rosenberry 1995). In the Dougherty Plain, this shallow groundwater system is referred to as residuum groundwater. Residuum groundwater elevations and dynamics are a function of rainfall, evapotranspiration, soils, topography and stage and dynamics of the deeper Floridan aquifer (Torak et al. 1991, 1996, Hicks et al. 1981). In our study area, the Floridan aquifer can be as little as one meter below the lowest elevation wetland. The chemistry of the wetlands do not indicate a direct discharge of the Floridan aquifer into the wetlands (Blood, unpublished data). The most likely mechanism explaining the significant relationship between wetland elevation and aquifer elevation was the aquifer water elevations influencing residuum elevation and, therefore, the antecedent conditions of the surrounding watershed groundwater elevations. Torak et al. (1996) identified a region encompassing a portion of our study area as a vertical discharge area (discharge head differentials of greater than 1.5 meters) of the Floridan into the unconsolidated residuum. Previous studies by the USGS found that the Floridan aquifer maintains a head pressure on the residuum during the seasonal high water periods and during this time the residuum dynamics are somewhat independent of the Floridan aquifer dynamics (Woody Hicks, per. com.). However, as the Floridan declined to seasonal lows and rose to seasonal highs, there was a direct relationship between the residuum elevations and the Floridan aquifer elevations. This relationship was clearly reflected in the non-linear analyses of wetland water elevation and Floridan aquifer elevation where below 41.5 m MSL there was a direct linear relationship with aquifer and above that elevation the wetland water level was a function of ET and rainfall. During seasonally high aquifer water elevations in 1994 and 1995, the wetlands responded to rainfall driven rises in the surrounding residuum water elevation but generally returned to a base water elevation that was characteristic for each wetland. This base elevation dropped as the aquifer declined and wetland water elevations declined. Several deviations from this relationship were observed. In the initial filling of the wetlands each year, the wetlands become inundated at the lowest aquifer water elevations when excess rainfall exceeds 200 mm and prior to the initiation of aquifer recharge. The occurrence of lower permeability soils in the wetlands and excess rain in the fall permitted ponding of water in the wetlands. If the aquifer continued to rise the wetlands remained inundated and wetland water elevations increased in proportion to aquifer water elevation increases. Large rain storms could override this general relationship and did result in temporary increases in wetland inundation during the aquifer water elevation recession.

Summary

The hydrodynamics of depressional wetlands in this study suggest a diversity of hydrologic controls. Two of the wetlands exhibited hydrodynamics which reflected local rainfall and evapotranspiration controls. The remaining eight wetlands hydrodynamics were dependent on the several apparently interconnected groundwater systems. Local wetland watershed groundwater elevation and rises with rainstorms maintains the seasonal wetland water hydroperiod and storm driven hydrodynamics. This watershed groundwater system is linked with the unconsolidated residuum groundwater dynamics and it in turn the Floridan aquifer groundwater dynamics. There are critical aquifer elevations in which all water systems are functioning in direct concert and thus to larger regional dynamics. In addition, there are Floridan aquifer elevations above which the residuum, watershed groundwater and wetlands are responding to local watershed/wetland controls (e.g. soil permeability) and local rainfall. These relationships dispute the previous held belief that depressional wetlands in the Dougherty Plain are independent ponded systems responding only to evapotranspiration and rainfall. This research suggests that the current Floridan aquifer removals for agriculture, industry and public drinking supply may be altering the historic wetlands hydrodynamics. The implications are that depressional wetlands in the Dougherty Plain do not have to be directly physically altered to alter hydrologic functioning. With the projected doubling of Floridan aquifer withdrawals in the next 20 years, special consideration should be given to the impacts that such withdrawals will have on depressional wetland hydrologic functioning.

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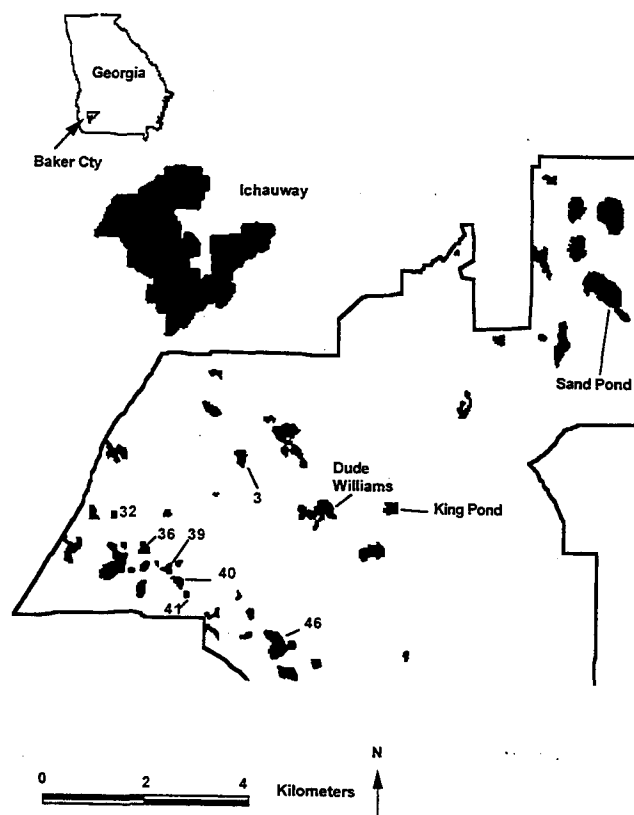


Figure 1. Wetland research site locations and place names.

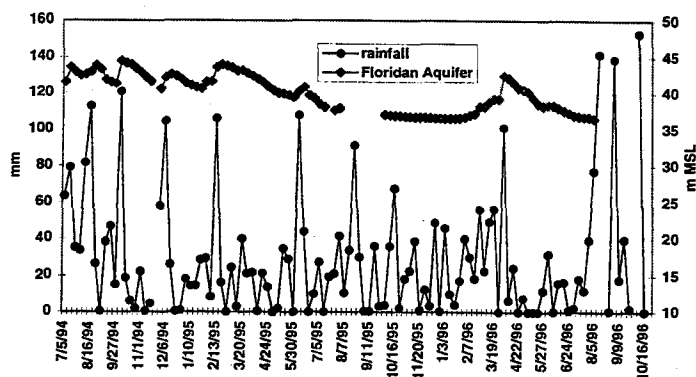


Figure 2. Total weekly rainfall amounts and Floridan aquifer elevations. The USGS Floridan Aquifer well (09H014) is located 12 km southwest of the center of the study site.